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(56) Documents cited
GB 1561886 A GB 1327992 A GB 1285319 A
GB 1228296 A

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(54) A mould for casting components

(57) A ceramic shell mould 30 for casting a turbine blade comprises an article portion 32 which has an article chamber 34 for defining the shape of the turbine blade. A secondary portion 38 which has a secondary chamber 40 is arranged such that the secondary chamber 40 extends parallel to a region 36 of the article chamber 34 which has reduced dimensions relative to the remainder of the article chamber. The secondary chamber 40 is spaced a small distance away from the region 36 so that bridging of the ceramic shell mould occurs to increase insulation around the region 36 and to provide molten metal in proximity to the region 36 to control heat loss from the region 36. The reduction of heat loss from the region 36 results in more uniform cooling of molten metal in the ceramic shell mould 30 and prevents the formation of undesired columnar grains in the trailing edge of the turbine blade which corresponds to the region 36 of the ceramic shell mould.

Fig.4

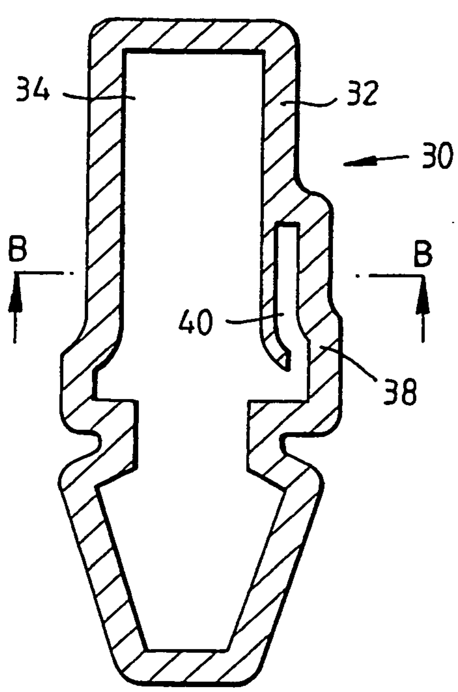
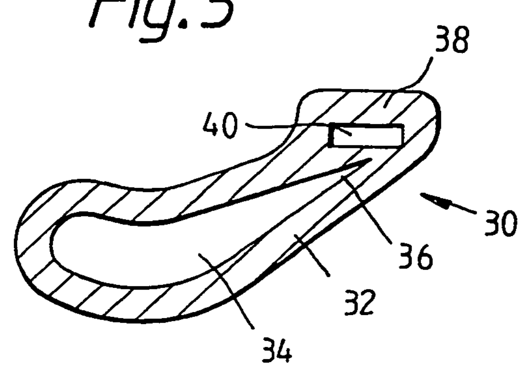


Fig.5



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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Fig.1

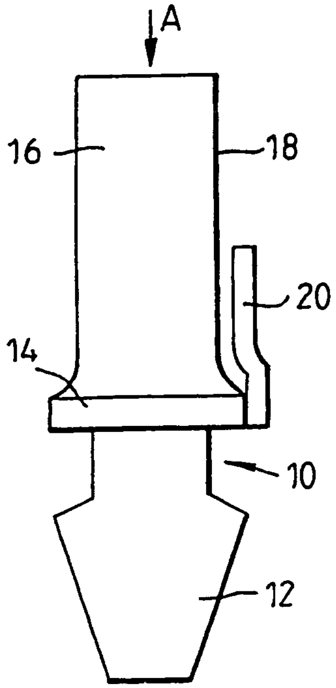


Fig.2

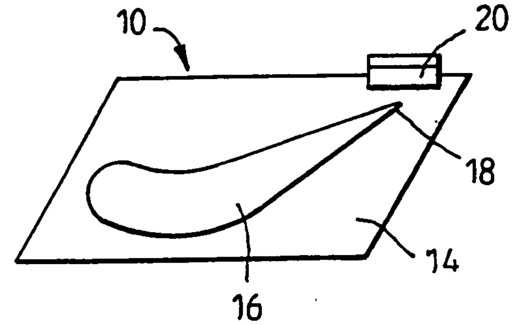


Fig. 3

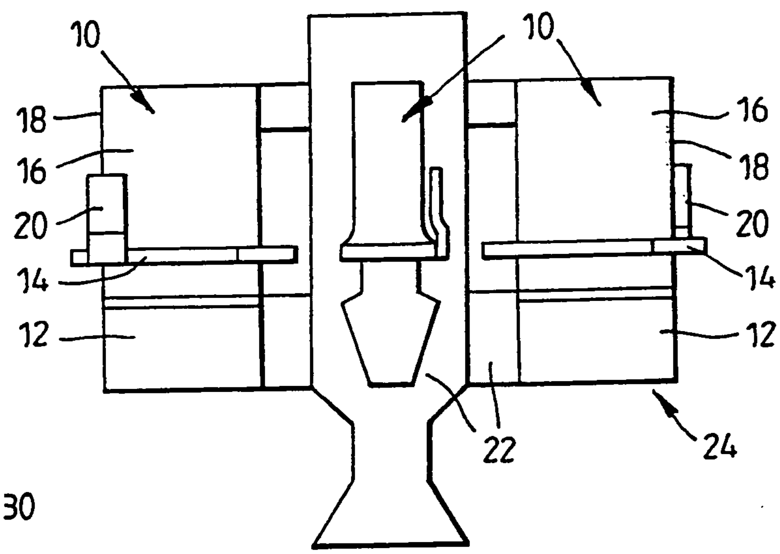


Fig.4

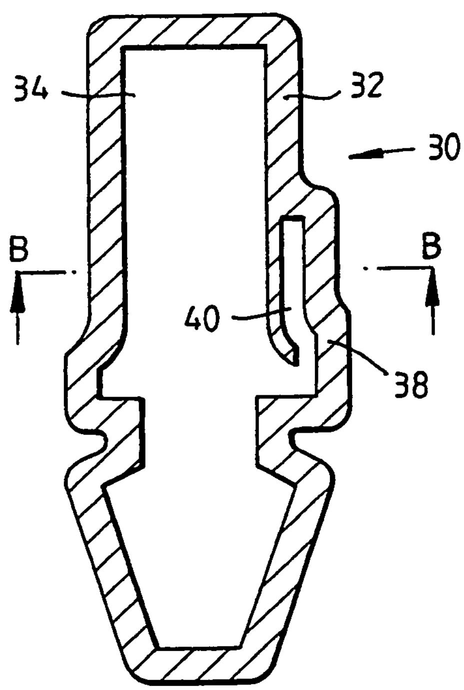
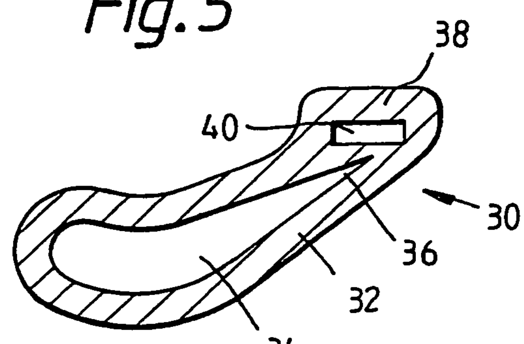


Fig.5



A MOULD FOR CASTING COMPONENTS

The present invention relates to moulds for casting components, and is particularly concerned with moulds used for lost wax casting, or investment casting, of components.

In the lost wax casting process a wax pattern of a component is produced. The wax pattern is a replica of the component to be produced. Usually a number of wax patterns are assembled together on a wax gating tree to form a cluster or wax mould assembly. The wax mould assembly is immersed in a liquid ceramic slurry which quickly gels after draining, strengthening refractory granules are sprinkled over the ceramic slurry covered wax mould assembly and the refractory granules bond to the slurry coating to produce a ceramic layer on the wax mould assembly. This process is repeated several times to produce many ceramic layers which have a total thickness of about 1/4 inch (6mm) to 1/2 inch (12mm) on the wax mould assembly. The wax is then melted out leaving a ceramic shell mould having an internal cavity identical in shape to that of the original wax cluster. This ceramic shell mould is called an investment casting mould. The mould is fired at a high temperature between 950°C and 1100°C to purify it by removing all traces of residual wax, while at the same time curing the ceramic mould. The ceramic shell mould is then transferred to a casting furnace, which may be operated at either a vacuum conditions or at atmospheric conditions. A charge of molten metal is then poured into the ceramic mould and the mould is allowed to cool to room temperature, after which the ceramic shell mould is removed leaving the cast component or components. The individual components are then removed from the gating tree and are chemically processed to remove ceramic residue.

A problem associated with the casting of components using the lost wax casting process is that undesirable columnar grains have appeared in regions of the finished component which have reduced dimensions relative to the remainder of the component. This is because the thermal

gradients in the molten metal in the mould are such that columnar grains are generated in the cooler regions of the mould, which have reduced dimensions relative to the remainder of the mould, and these grains grow towards the hotter regions of the mould. In particular turbine blades, or turbine vanes, for gas turbine engines have been produced which have columnar grains in the thin trailing edge region of the aerofoil which have grown towards the relatively massive root.

The presence of these columnar grains in the trailing edge region of the aerofoil of a turbine blade or turbine vane is undesirable because the grain size in the turbine blade or turbine vane has to be within predetermined limits for optimum characteristics.

Accordingly the present invention seeks to provide a mould for casting components which reduces the formation of columnar grains in a component cast in the mould.

Accordingly the present invention provides a ceramic shell mould for casting a component comprising at least one article portion having an article chamber to define the desired component, the article portion having a region of reduced dimensions relative to the remainder of the article portion, and means to control the loss of heat from any molten metal in the said region of the article chamber or to heat the said region of the article chamber of the at least one article portion.

Preferably the mould comprises at least one secondary portion which has a secondary chamber, the at least one secondary portion is arranged such that any molten metal in the at least one secondary chamber is relatively close to at least part of the said region of the article chamber to control the loss of heat from any molten metal in the said region of the article chamber or heat the said region of the article chamber of the at least one article portion.

Preferably the ceramic shell mould is for casting a turbine blade or a turbine vane.

Preferably the secondary portion is arranged relative to the article portion such that the secondary chamber is relatively close to the region of the article chamber defining the trailing edge of the turbine blade or turbine vane.

Preferably the secondary portion is arranged to extend substantially parallel to the region of the article chamber defining the trailing edge region of the turbine blade or turbine vane.

Preferably the secondary chamber is interconnected to the article chamber at a region of the article portion defining the root or platform of the turbine blade or turbine vane.

Preferably the space between said region of the article chamber having reduced dimensions relative to the remainder of the article portion and the secondary chamber is less than 2 mm.

Preferably the space is 1mm.

Preferably the ceramic shell mould of the secondary portion and the ceramic shell mould of the region of the article portion having reduced dimensions relative to the remainder of the article portion are joined together.

Preferably the ceramic shell mould comprises a plurality of article portions and a plurality of secondary portions, each secondary portion is arranged relative to a respective one of the article portions such that the secondary chamber is relatively close to at least part of the said region of the article chamber to control the loss of heat from said region of the article chamber of the at least on article portion.

The secondary chamber may be interconnected with the article chamber.

The present invention also provides a ceramic shell mould for casting a component comprising at least one article portion having an article chamber to define the desired component, the article portion having a region of

reduced dimensions relative to the remainder of the article portion, at least one secondary portion having a secondary chamber, the at least one secondary portion being arranged such that any molten metal in the at least one secondary chamber is relatively close to at least a part of the said region of the article chamber to control the loss of heat from any molten metal in the said region of the article chamber or heats the said region of the article chamber of the at least one article portion.

The present invention will be more fully described by way of example, with reference to the accompanying drawings in which:-

Figure 1 is a view of a wax pattern for making a mould according to the present invention.

Figure 2 is a view in the direction of arrow A in figure 1.

Figure 3 is a view of a wax mould assembly for making a mould according to the present invention.

Figure 4 is a cross-sectional view through a mould according to the present invention using the wax pattern shown in figures 1 and 2, and

Figure 5 is a cross-section along line B-B in figure 4.

A wax pattern 10, shown in figures 1 and 2, is suitable for making turbine blades or turbine vanes for gas turbine engines. The wax pattern 10 has a first part 12, which defines the shape of the root of the resulting cast turbine blade, a second part 14, which defines the shape of the platform of the resulting cast turbine blade, a third part 16, which defines the shape of the aerofoil of the resulting cast turbine blade. The third part 16 of the wax pattern has a region 18 which is very thin in order to define the trailing edge region of the aerofoil of the resulting cast turbine blade. The wax pattern 10 also has a fourth part 20, which is interconnected to the second part 14 of the wax pattern 10 and which extends substantially parallel to the region 18 of the third part 16. The fourth

part 20 is arranged very close to, but is spaced from, the region 18 of the third part 16 which is very thin compared to the remainder of the wax pattern 10. The fourth part 20 is positioned up to 2mm from the region 18 and preferably the spacing is 1mm. The fourth part 20 is arranged as close as possible to the region 18.

A number of these wax patterns 10 are arranged together on a wax gating tree 22 to form a wax mould assembly 24, shown in figure 3. The wax patterns 10 are interconnected to the wax gating tree 22 at two positions in this example.

The wax mould assembly 24, including the wax patterns 10, is immersed in liquid ceramic slurry and has refractory granules sprinkled on the gelling liquid ceramic slurry to produce a layer of ceramic. The process of immersing the wax mould assembly 24 in liquid ceramic slurry and sprinkling with refractory granules is repeated until the thickness of ceramic is sufficient for the particular application. The thickness of ceramic normally used is 6mm to 12mm. The ceramic shell mould joins together where the region 18 of the third part 16 and the fourth part 20 of the individual wax patterns 10 are close together.

Figures 4 and 5 show a ceramic shell mould 30 for casting a turbine blade made from the wax mould assembly 24 shown in figure 3. The ceramic shell mould 30 comprises a number of article portions 32 each of which has an article chamber 34 to define the turbine blade. The article portion 32 has a region 36, corresponding to region 18 of the wax pattern 10, which has reduced dimensions relative to the remainder of the article portion 32. The ceramic shell mould 30 also has a number of secondary portion 38 each of which has a secondary chamber 40 interconnected with the article chamber 34 of a respective one of the article portions 32. Each secondary portion 38 is arranged relative to the respective article portion 32 such that the secondary chamber 40 is relatively close to at least part of the region 36 of the article chamber 34, i.e. within

2mm. The secondary chamber 40 is arranged as close as possible to the region 36 of the article chamber 34, within the constraints of the investment casting process. The ceramic shell mould also comprises a number of runner chambers which convey molten metal to the article chambers 34 and secondary chambers 40.

When molten metal is poured into the ceramic shell mould 30, the molten metal fills the article chambers 34 and the secondary chambers 40. One effect of the secondary chambers 40 is to increase the thickness of the ceramic, and hence to increase the insulation, at the region 36 of the article portions 32 of the ceramic shell mould 30 compared to the prior art. In the prior art ceramic shell mould the ceramic, and hence the insulation, is thinner at the region of the ceramic shell mould defining the trailing edge of the turbine blade. A further effect of the secondary chambers 40 is that the molten metal in the secondary chambers 40 retains heat locally in the proximity of the regions 36, and heat from the molten metal is transmitted to the molten metal in the regions 36. The molten metal in the secondary chambers 40 acts as a heater for the molten metal in the regions 36 of the article chambers 34. The combination of these two effects is that there is more uniform cooling of the molten metal in the article portions 32 of the ceramic shell mould 30 and the formation of columnar grains in the regions 36 of the article chambers 34 is prevented or reduced. The secondary chambers 40 control the thermal gradients in the molten metal in the article chambers 34 of the article portions 32 and thus reduces or prevents the formation of the columnar grains in the regions 36 of the article chambers 34.

After the metal has solidified in the ceramic shell mould 30, the ceramic shell mould 30 is removed to reveal the cast turbine blades or turbine vane. The metal which solidified in the secondary chambers 40 is then cut off the cast turbine blade.

The invention is applicable to the production of cast turbine blades or vanes with random grain growth sometimes known as equiaxed turbine blades or vanes. The invention may also be applicable to directionally solidified turbine blades or vanes and to single crystal turbine blades or vanes. The invention may also be used for the production of other components or articles in which the control of the metallic grains is important.

Although the description has referred to the use of a ceramic shell mould which comprises a number of article portions and a number of secondary portions, it is equally possible to have a ceramic shell mould which has only a single article portion and an associated secondary portion. It may also be suitable in particular circumstances, depending on the shape of the component to be cast, to have more than one secondary portion for each article portion in order to prevent the formation of columnar grains in the molten metal at a number of regions in the article portion. The shape of the secondary chambers in the secondary portion may be shaped to conform to the adjacent shape of the region of the article chamber of the article portion.

Although the description has referred to interconnecting the secondary chambers to a specified part of the article chamber, the secondary chambers may be interconnected to any convenient part of the article chamber, and may be interconnected to any convenient part of the runner chambers initially defined by the wax gating tree.

The secondary portions may also be used to reduce porosity defects by controlling the thermal gradients required for efficient feeding of molten metal during solidification. The secondary portions may also be used to reduce chill grain defects and misruns.

Chill grain defects occur when the molten metal solidifies rapidly in a region of the mould to produce a very fine grained structure, and the remainder of the molten metal in the mould solidifies more slowly to produce

a coarser grained structure. The interface between the fine and coarse grained structures in the cast metal component produces a weakness in the cast metal component. The secondary portions may be used to heat the region of the mould where fine grained structures normally occur, i.e. regions of reduced dimension, to increase the solidification time in that region to produce coarser grains.

Misruns occur when the molten metal has not filled a region of the mould which has reduced dimensions. This may be caused because of insufficient kinetic energy in the molten metal, or because low metal temperature produces increased viscosity of the molten metal preventing the molten metal flowing into the region of the mould. The secondary portions may be used to heat the regions of the mould which have reduced dimensions to decrease the viscosity of the molten metal so that it may flow into the region of the mould.

Claims:-

1. A ceramic shell mould for casting a component comprising at least one article portion having an article chamber to define the desired component, the article portion having a region of reduced dimensions relative to the remainder of the article portion, and means to control the loss of heat from any molten metal in the said region of the article chamber or to heat the said region of the article chamber of the at least one article portion.

2. A ceramic shell mould as claimed in claim 1 in which the mould comprises at least one secondary portion having a secondary chamber, the at least one secondary portion being arranged such that any molten metal in the at least one secondary chamber is relatively close to at least part of the said region of the article chamber to control the loss of heat from any molten metal in the said region of the article chamber or heats the said region of the article chamber of the at least one article portion.

3. A ceramic shell mould as claimed in claim 2 in which the ceramic shell mould is for casting a turbine blade or a turbine vane.

4. A ceramic shell mould as claimed in claim 3 in which the secondary portion is arranged relative to the article portion such that the secondary chamber is relatively close to the region of the article chamber defining the trailing edge of the turbine blade or turbine vane.

5. A ceramic shell mould as claimed in claim 3 or claim 4 in which the secondary portion is arranged to extend substantially parallel to the region of the article chamber defining the trailing edge region of the turbine blade or turbine vane.

6. A ceramic shell mould as claimed in claim 3, claim 4 or claim 5 in which the secondary chamber is interconnected to the article chamber at a region of the article portion defining the root or platform of the turbine blade or turbine vane.

7. A ceramic shell mould as claimed in any of claims 2 to 6 in which the space between said region of the article chamber having reduced dimensions relative to the remainder of the article portion and the secondary chamber is less than 2 mm.

8. A ceramic shell mould as claimed in claim 7 in which the space is 1mm.

9. A ceramic shell mould as claimed in any of claims 2 to 8 in which the ceramic shell mould of the secondary portion and the ceramic shell mould of the region of the article portion having reduced dimensions relative to the remainder of the article portion are joined together.

10. A ceramic shell mould as claimed in any of claims 3 to 6 for
casting a equiaxed turbine blade or turbine vane.

11. A ceramic shell mould as claimed in any of claims 2 to 10 comprising a plurality of article portions and a plurality of secondary portions, each secondary portion is arranged relative to a respective one of the article portions such that the secondary chamber is relatively close to at least part of the said region of the article chamber to control the loss of heat from said region of the article chamber of the at least on article portion.

12. A ceramic shell mould as claimed in any of claims 2 to 11 in which the secondary chamber is interconnected with the article chamber.

13. A ceramic shell mould substantially as hereinbefore described with reference to figures 4 and 5 of the accompanying drawings.

14. A ceramic shell mould for casting a component comprising at least one article portion having an article chamber to define the desired component, the article portion having a region of reduced dimensions relative to the remainder of the article portion, at least one secondary portion having a secondary chamber, the at least one secondary portion being arranged such that any molten

metal in the at least one secondary chamber is relatively close to at least a part of the said region of the article chamber to control the loss of heat from any molten metal in the said region of the article chamber or heats the said region of the article chamber of the at least one article portion.

15. A cast article produced from a ceramic shell mould according to any preceding claim.

Patents Act 1977
Examiner's report to the Comptroller under Se. on 17 (The Search Report)

Application number

9119854.9

Relevant Technical fields

(i) UK Cl (Edition K) B3F FGK, FGL, FGM, FGP

(ii) Int Cl (Edition 5) B22C; B22D

Search Examiner

J A WALLIS

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES WPI:

Date of Search

3 DECEMBER 1991

Documents considered relevant following a search in respect of claims 1 AND 14 AT LEAST

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 1561886 (Howmet) exemplifies which plate controlling heat loss at 'smaller' end of blade 26	1 and 15 at least
X	GB 1327992 (United Aircraft) NB. figure 7	1 and 15 at least
X	GB 1285319 (United Aircraft) eg. secondary chambers 20 eg. figure 1	1-5,11, 12,14,15 at least
X	GB 1228296 (United Aircraft) recess 34 at trailing edge	1,2 and 14 at least

Category	Identity of document and relevant passages	Relevant to claim(s.

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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